Instabilities and Discontinuities in Two-Phase Media

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ABSTRACT

Within the framework of the generalised theory of heterogeneous media, the complete set of equations is derived for a three-dimensional fluid-saturated porous medium. Subsequently, dispersion analyses are carried out for an infinite one-dimensional continuum, that has been deforming homogeneously prior to the application of the perturbation. A dispersive wave is obtained, but the internal length scale associated with it vanishes in the short wave--length limit, at least for the assumptions made regarding the constitutive behaviour of the solid and of the fluid. This result leads to the conclusion that, upon the introduction of softening, localisation in a zero width will occur and no regularisation will be present. This conclusion is corroborated by the results of numerical analyses of wave propagation in a finite one-dimensional bar [1]. The result has severe implications for finite element analyses of damaging multiphase media, since they will be mesh-dependent.

To avoid mesh dependence, either the constitutive model for the solid must be equipped with a nonvanishing internal length scale, or any damage that occurs must be modelled in a strictly discrete manner. The second part of the contribution therefore focuses on the proper modelling of discontinuities in fluid-saturated porous media. A two-field finite element formulation has been set up with the displacements and the fluid pressure as the fundamental unknowns [2]. At discontinuities in the body, e.g. cracks, the displacement and the fluid pressure fields are allowed to be discontinuous. Numerically, the discontinuities in the displacements and the fluid pressure are incorporated using the partition-of-unity property of finite element shape functions.

The tractions at the interface are related to the displacement jumps using a cohesive zone model, where the behaviour in the direction normal to the interface can be different from that in the tangential direction. Regarding the pore fluid flow, it has been assumed that the normal flux to the interface is proportional to the jump in pore pressures at both sides of the discontinuity, which can be conceived as the discrete analogon of Darcy's relation for fluid flow in porous media. The paper concludes with some examples of finite element analyses of fluid-saturated porous media with discontinuities.

References

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